3. It can distinguish between structures as small as 2 nm (NANOMETERS), 100 x better than the light microscope (1/BILLIONTH METER)
4. So biologists can explore the ULTRASTRUCTURE, INTERNAL anatomy of the cell
5. The highest in the book is 100,000 X

E. Two types of Electron Microscopes

1. SCANNING electron microscope
   a. Studies detail the cell SURFACES after they are coated with a thin FILM of metal
   b. It detects electrons and TRANSLATES the patterns into an image for a video screen (4.1C)
2. TRANSMISSION electron microscope
   a. Studies the INTERNAL cell structure after the specimen is cut into THIN SLICES and stained with atoms of a HEAVY METALS which attaches to certain cellular structures more than others
   b. The electron beam is aimed THROUGH the thin section and the image created by the pattern of electrons
   c. It uses ELECTROMAGNETS as lenses to bend the electron beam instead of glass lenses
   d. P. 53, Figure 4.1D shows the original black and white, then colorized
3. Problems – can't be used to study LIVING specimens because the preparation methods KILL the cells

F. Different types of Light Microscopes

1. Differential Interference - CONTRAST microscope (P. 53, Fig. 4.1E) that amplifies the differences in DENSITY while showing living cells
2. Fluorescence and Confocal microscopy
   a. Where specific molecules are TAGGED with fluorescent DYES which bind to various cellular molecules
   b. An "OPTICAL SECTIONING" technique then brings a very thin section of the cell into focus and you get a 3D RECONSTRUCTION of the sample

4.2 MOST CELLS ARE MICROSCOPIC

A. Most cells cannot be seen with the NAKED eye

B. MYCOPLASMS are the smallest cells - .03 µm

C. Some of the bulkiest are BIRD'S EGGS, the longest are MUSCLE and NERVE cells

D. Most plant and animal cells range from 10-100 µm in diameter (10x larger than most bacteria)

5. Some have another STICKY layer called a CAPSULE to further protect and GLUE the prokaryote to surfaces

6. Some have short projections called PILI (PILUS) to help them attach

7. FLAGELLA, whip like tails, help to propel them through liquids

4.4 EUKARYOTIC CELLS ARE PARTITIONED INTO FUNCTIONAL COMPARTMENTS

A. Eukaryote (Eu – true, karyon – kernel)

B. Figure 4.4A, P. 56 is an IDEALIZED animal cell

1. Has a nucleus with NUCLEOLUS, chromosomes, and a nuclear membrane

2. Has ORGANELLES ("little organs") – perform specific functions

3. Four basic functional groups

a. Nucleus, ribosomes, endoplasmic reticulum, Golgi - MANUFACTURING

b. Lysosome, vacuoloes, peroxisomes - BREAK DOWN or HYDROLYSIS

c. Mitochondria, chloroplast - ENERGY PROCESSING

d. Cytoskeletom, plasma membrane, cell wall – structural support, MOVEMENT, COMMUNICATION

C. Internal membranes partition the cell into compartments (organelles)

1. Cellular METABOLISM - chemical activities of cells occur in organelles

2. Many enzymatic proteins are built into the MEMBRANES of the organelle

3. Fluid-filled spaces within an ~~organism~~ CELL are sites where specific chemical REACTIONS are maintained as in hydrogen peroxide breakdown in the PEROXISOME

D. Differences between plant and animal cells (P. 56-57, Fig 4.4 A,B)

	PLANT	ANIMAL
1. Lysosomes, centrioles	NO	YES
2. Flagella, cilia	ONLY SPERM	YES
3. Cell walls w/ cellulose and plasmodesmata	YES	NO
4. Chloroplasts	YES	NO
5. Large central vacuole	YES	NO

4.7 RIBOSOMES MAKE PROTEINS FOR USE IN THE CELL AND FOR EXPORT

A. Carries out protein synthesis

B. Found in two locations

1. FREE ribosomes – in the cytoplasm
2. ATTACHED ribosomes – attached to the endoplasmic reticulum or nuclear envelope

C. Composed of LARGE and SMALL subunits

D. Proteins made on the free ribosomes function in the CYTOPLASM like enzymes for sugar breakdown; protein made on the bound ribosomes will be INSERTED into membranes, packaged in certain organelles or EXPORTED from the cell (as in gland cells)

4.8 OVERVIEW: MANY CELL ORGANELLES ARE CONNECTED THROUGH THE ENDOMEMBRANE SYSTEM

A. Some are PHYSICALLY connected, others are related by TRANSFER of membrane segments by tiny VESICLES, sacs made of membrane

B. Includes the NUCLEAR envelope, endoplasmic reticulum, GOLGI, LYSOSOMES, vacuoles and plasma membrane

C. They work together in SYNTHESIS, STORAGE and export of molecules

D. Endoplasmic reticulum – a NETWORK of FLATTENED sacs and tubules (endoplasmic – within the cytoplasm, reticulum – "little net")

E. It is continuous with the NUCLEAR ENVELOPE

F. It encloses an interior space that is separate from the cytoplasmic FLUID, dividing the cell into compartments

4.9 THE ENDOPLASMIC RETICULUM IS A BIOSYNTHETIC FACTORY

A. Interconnecting membranes (P. 60, Fig. 4.9A)

1. ROUGH ER – with ribosomes
2. SMOOTH ER – without ribosomes

B. Smooth ER

1. Functions in diverse METABOLIC processes
   a. Synthesis of LIPIDS (oils), phospholipids, and STEROIDS
      1) Ovaries and testes synthesize SEX hormones
      2) Lots of smooth ER with spaces for STEROID synthesis

4.11 LYSOSOMES ARE DIGESTIVE COMPARTMENTS WITHIN A CELL

A. Consists of digestive enzymes enclosed in a membranous sac

B. Gr. – "BREAKDOWN body"

C. Enzymes are made by ROUGH ER then to the Golgi

D. Lysosomal membranes enclose a compartment in which digestive enzymes are provided with an ACIDIC environment and are safely ISOLATED from the rest of the cell

E. Functions

1. Lysosomes FUSE with food vacuoles in protists to breakdown FOOD
2. WHITE blood cells ingest BACTERIA into vacuoles which join with lysosomes
3. Serve as RECYCLING centers for animal cells, sending parts back for REUSE

F. Lysosomal Storage Diseases

1. Occur when one or more of the ENZYMES is missing or abnormal
2. Lysosomes become ENGORGED with UNDIGESTED materials and eventually interfere with cell functions
3. TAY - SACHS is an examples where BRAIN cells become impaired with an accumulation of LIPIDS and the child usually DIES by age 5

LORENZO'S OIL

4.12 VACUOLES FUNCTION IN THE GENERAL MAINTENANCE OF THE CELL

A. Membranous SAC with a variety of functions

B. Figure 4.12A shows a plant cell central vacuoles with HYDROLYTIC function like a lysosome

1. Also helps the cell GROW in size by absorbing WATER and enlarging
2. Can store vital chemicals or WASTE products

C. In flower petals, store PIGMENTS in CHROMAPLASTS (chroma – color)

D. Also can contain POISONS to protect it against predators (strychnine, nicotine)

E. In paramecium, the vacuole has "SPOKES" to collect excess water and pumps it to the outside – (called a CONTRACTILE vacuole)

F. In potatoes, STARCH is stored in LEUCOPLASTS (leuco – white)

4.13 A REVIEW OF THE STRUCTURES INVOLVED IN MANUFACTURE AND BREAKDOWN

A. There are direct STRUCTURAL connections between nuclear envelope, rough and smooth ER

B. There are FUNCTIONAL connections between proteins made by the ER that travel in TRANSPORT vesicles to the GOLGI → other destinations

D. Both are surrounded by a DOUBLE membrane and the inner one is similar to the PLASMA membrane of prokaryotes

E. Hypothesis - ENDOSYMBIOSIS

1. The mitochondria and chloroplasts were formerly small PROKARYOTES that began living WITHIN larger cells
2. The endosymbiont is a cell that lives INSIDE another (HOST)
3. Could have been UNDIGESTED prey or an internal PARASITE
4. Symbiosis could have become BENEFICIAL
   a. The host uses nutrients released from a PHOTOSYNTHETIC endosymbiont
   b. The larger cell also would have benefited from the endosymbiont that was able to use O_2 to release large amounts of ENERGY in cell respiration
   c. Over time, the host and endosymbiont would have become more INTERDEPENDENT
5. The theory is that the MITOCHONDRIA evolved before the CHLOROPLAST because all cells have mitochondria but not all have chloroplasts

INTERNAL AND EXTERNAL SUPPORT: THE CYTOSKELETON AND CELL SURFACE

4.17 THE CELL' S INTERNAL SKELETON HELPS ORGANIZE ITS STRUCTURE AND ACTIVITIES

A. Improved microscopes allowed scientists to see that cell parts just don't FLOAT around but are held in place by a NETWORK of fibers, the CYTOSKELETON
B. Movement within cells and the LOCOMOTION of cells requires MOTOR proteins

C. It may also be involved in TRANSMITTING signals from the SURFACE to the INTERIOR

D. Three kinds of fibers (P. 65, Fig. 4.17)

1. MICROFILAMENTS
   a. Thinnest made of ACTIN
   b. SOLID and arranged in a double TWIST
   c. 3D network inside the plasma membrane to help support cell SHAPE
   d. Involved in cell MOVEMENTS as in MUSCLE contraction and AMEBOID movement in Ameba or WHITE blood cells
2. INTERMEDIATE
   a. Made of various proteins with ROPE-like structure
   b. Reinforce cell shape and ANCHOR certain organelles, like the NUCLEUS, in a cage of intermediate fibers
   c. Microfilaments may be DISASSEMBLED and REASSEMBLED elsewhere but intermediate fibers are more PERMANENT
   d. Outer skin layers of DEAD skin cells full of intermediate filaments of KERATIN
3. MICROTUBULES
   a. Straight, HOLLOW tubes of TUBULIN
   b. Elongate by adding subunits of tubulin pairs (DIMERS)

B. Extracellular matrix (ECM)

1. Helps holds cells TOGETHER in tissues

2. Protects and supports the PLASMA membrane
3. The main components are GLYCOPROTEINS (collagen) that forms strong FIBERS outside the cell
4. Large complexes form and connect the a central long POLYSACCHARIDE molecule

5. The extracellular matrix may attach it to the cell by INTEGRINS that span the membrane connecting the microfilaments on the other side

   a. Function of INTEGRATION - transmit information between ECM and cytoskeleton
   b. Can regulated a cell's BEHAVIOR, directing the path along which embryonic cells move and influence the action of GENES

4.21 THREE TYPES OF CELL JUNCTIONS ARE FOUND IN ANIMAL TISSUE (P. 68, Fig. 4.21)

A. TIGHT junctions

1. Membranes of neighboring cells are TIGHTLY pressed against each other and KNIT together with proteins
2. Prevents LEAKAGE of extracellular fluid as in the digestive system

B. ANCHORING junctions

1. Function like RIVETS, fastening cells together into strong SHEETS
2. Intermediate filaments of KERATIN anchor these
3. Common in tissue subjected to STRETCHING or mechanical stress (skin, heart, muscles)

C. GAP junctions or COMMUNICATING junctions

1. CHANNELS that allow small molecules to flow through protein-lined pores to neighboring cells

2. Example - IONS in heart muscle and common in animal embryos where chemical communication is essential for development

4.22 CELL WALLS ENCLOSE AND SUPPORT PLANT CELLS (P. 68, Fig. 4.22)

A. Cell wall – distinguishes PLANT cells from ANIMAL cells

1. Protests and provide SKELETAL support

2. 10-100 times thicker than the plasma membrane with fibers of CELLULOSE embedded in the matrix of other polysaccharides and proteins

B. Layers of the wall

1. PRIMARY wall

   a. Thin and FLEXIBLE
   b. Allows the cell to continue to ENLARGE